ICE Topic Modules 2026-2027

10.492A *Biomolecular Systems*, Prof H. Sikes

Prof. Sikes' Research Overview:
Our efforts focus on engineering biomolecular systems to detect and treat disease in new ways. We use the principles of engineering design to support and extend the practice of evidence-based diagnosis and selection of therapy.

Engineering design starts with interviewing intended users to formulate a quantitative problem statement and to understand the context and constraints for a new medical test. In the area of infectious disease, proteins in bodily fluids can indicate malaria or tuberculosis. The protein identity, quantity, and bodily fluid vary with the disease. In cancer, particular epigenetic and post-translational protein modifications can predict which therapies are likely to be effective against an individual tumor. We use an understanding of thermodynamics, kinetics, and transport phenomena to design medical tests that simultaneously meet design criteria for analytical performance, assay time, cost, robustness, and infrastructural requirements. We iteratively test prototypes with clinical collaborators to assess and improve real-world utility.

10.493 *Electrochemical Energy*, Prof J. Drake

Energy technology plays a critical role on an individual and societal scale. Electrochemical energy conversion systems, such as batteries and fuel cells, find applications in personal power--e.g., handheld electronic devices; stationary home power; vehicles; and large-scale power plants. Design, sizing, and choice of operating points are important considerations for appropriately engineering these potentially efficient electrochemical systems. Lectures and assignments address the ways that thermodynamics, electrochemical reactions, and transport factor into power, durability, and efficiency trade-offs. For the project, each group undertakes a detailed analysis of a single or hybrid combination of power sources, leading to design choices targeting a particular device and consumer use.

10.494A *Electrocatalysis*, Prof K. Yap

With an increasing abundance of renewable energy, chemical conversions driven by electricity are becoming increasingly desirable. In this course, we will explore the fundamentals of electrocatalysis and the potential integration of this technology to a renewable energy landscape. We will begin with an emphasis on how thermodynamics, kinetics, and transport phenomena influence the performance of reactions at electrocatalytic interfaces. With this knowledge, we will discuss how material design and reactor engineering can be used to steer electrocatalytic performance. Finally, we will identify major barriers between fundamental electrocatalysis research and commercial implementation. Projects will focus on investigating potential pathways to accelerating the transition to electrified chemical conversions.

10.494B Therapeutic Nanoparticle Manufacturing, Prof D.G. Anderson

Lipid nanoparticles are poised to revolutionize the treatment of genetic disease by enabling the therapeutic delivery of nucleic acids that can turn your genes off, turn them on, or even permanently and specifically edit your genome. This class will provide an overview of lipid nanoparticles and drug delivery including what nanoparticles are made of, how they will be used, and in particular how they are made and analyzed.

Projects will focus on the application of chemical engineering principles to design a continuous nanoparticle formulation process for pharmaceutical-scale production. This will include examination of small-scale nanoparticle production procedures based on microfluidics, hands-on construction of nanoparticle formulation chips, and a study of how these devices might be adjusted to meet the needs of commercial-scale production.